

Angiographical Follow-up Results of Cerebral Aneurysms Treated by Guglielmi Detachable Coil System

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Summary

To examine the long term results of endovascular treatment of cerebral aneurysms with the Guglielmi detachable coil (GDC) system, follow-up (F/U) angiography was performed at 6, 12 and 24 months after the procedure. We analyzed 45 cases, 49 procedures of GDC treated cerebral aneurysms from 1997.6. to 2000.5. Follow-up angiography was achieved at 6M 43/45 (96%), 12M 29/33 (87%) and 24M 22/25 (88%). Angiographical changes were found 23/43 (53%) of the cases at 6M F/U. There were angiographical improvements in 12 cases (CP: complete occlusion, NR: neck remnant, PA: partial occlusion, PA-CP; 8, NR-CP; 1, PA-NR; 3) and angiographical worsening in 11 cases (CP-NR; 5, CP-PA; 3, PA-PA; 3) at 6M F/U. Two cases had been demonstrating progressive angiographical worsening at 6M and 12MF/U (CP-NR-PA). No angiographical change was found at 24MF/U. There was no case of hemorrhage or re-hemorrhage after GDC treatment. In cases of side-wall aneurysm, tight packing of the inflow side of the aneurysm and small neck aneurysm were thought to be causes of the angiographical improvements. In patients with wide neck aneurysms with partial occlusion result were angiographic worsening at the F/U. Other factors of angiographical worsening were improper working angle at the procedure and improper

follow-up angle at the angiography and the intraluminal clot in the case of ruptured aneurysm.

Introduction

Endovascular treatment of cerebral aneurysm with GDCs is now widely accepted as a therapeutic alternative of cerebral aneurysm¹⁻⁴ and over 60,000 aneurysms have been treated all over the world. Japanese FDA accepted endovascular treatment of cerebral aneurysm with GDC system in 1997.3 and over 4,000 aneurysms have been treated by this technique. Aneurysm coil embolization has a potential risk of aneurysm recurrence by coil compaction and follow-up examination is important and necessary to determine the final result³⁻⁸. In this report, the follow-up angiography was performed with very high percentages (6M/96%, 12M/88%, 24M/88%) and serial follow-up angiography was performed to follow the initial follow-up change.

Materials and Methods

Since 1997.6 to 2000.5, we have had 45 cases, 49 procedure of GDC aneurysm embolization with over 6 months follow-up, averaged follow-up period was 20.7 months. They consisted 27

cases of female and 18 cases of male, ages were 33 to 75. Locations of the aneurysms were ICA aneurysm 17 cases, ACA aneurysm 12 cases, MCA aneurysm 8 cases, Vertebral-basilar system aneurysm 7 cases and multiple aneurysms 1 case. Ruptured aneurysms were 9 cases and non-ruptured aneurysms were 36 cases. The sizes of the aneurysms were less than 10 mm size in 41 cases, 10 to 25 mm in 4 cases and no giant aneurysm case in this series.

Results

Follow-up angiography performance rate

Six months follow-up angiography was performed in 43/45 (96%) of the candidates. There was a case of rejecting follow-up angiography and a case of lost by social reason. Twelve months follow-up angiography was performed in 29/33 (88%) of the candidates. There were a case of rejecting follow-up angiography and three cases of lost of follow-up. Two cases were treated by second GDC embolization and one case was treated by surgical clipping after 6 months follow-up. Twenty-four months follow-up angiography was performed in 22/25 (88%) of the candidates. There was a case of rejecting follow-up angiography and two cases of lost of follow-up.

Angiographical follow-up results of 6 months follow-up

Twenty cases out of 43 cases (47%) had no angiographical change. They were complete occlusion (CP) to CP in 18 cases and neck remnant (NR) to NR in 2 cases. Twelve cases out of 43 cases (28%) demonstrated angiographical improvements, NR to CP in 1 case, PA to CP in 8 cases and PA to NR in 3 cases. Eleven cases out of 43 cases (26%) demonstrated angiographical worsening, CP to NR in 5 cases, CP to PA in 3 cases and PA worsening in 3 cases.

Angiographical follow-up results of 12 months follow-up

Twenty-six cases out of 29 cases (90%) had no angiographical change. They were complete occlusion (CP) to CP in 21 cases, neck remnant (NR) to NR in 4 cases and partial occlusion without change in 1 case. There was no case of demonstrating angiographical improvement at 12 months follow-up. There were three cases

(10%) of angiographical worsening at 12 months follow-up. Two of them were demonstrating progressive worsening from initial results to 6M and 12M F/U, and the other one was because of improper angle in follow-up angiography.

Angiographical follow-up results of 24 months follow-up

All twenty-two cases (100%) had demonstrated no angiographical change at 24 months follow-up. They were CP to CP in 18 cases, NR to NR in 2 cases and PA without change in 2 cases.

Location of the aneurysm and the angiographical follow-up outcome

Initial GDC aneurysm embolization results and the final angiographical follow-up results were compared in relation with the locations of the aneurysms.

In ICA aneurysms, 6 out of 17 cases (35%) demonstrated no angiographical change. They were CP to CP in 5 cases and NR to NR in 1 case. Seven cases (41%) demonstrated angiographical improvements, PA to CP in 6 cases and PA to NR in 1 case. Four cases (24%) demonstrated angiographical worsening, CP to NR in 2 cases and PA with worsening in 2 cases.

In ACA aneurysms, 4 out of 11 cases (36%) demonstrated no angiographical change. They were CP to CP in 4 cases. Three cases (28%) demonstrated angiographical improvements, NR to PA in 1 case and PA to CP in 2 cases. Four cases (36%) demonstrated angiographical worsening, CP to NR in 1 case and CP to PA in 3 cases.

In MCA aneurysms, 5 out of 7 cases (71%) demonstrated no angiographical change. They were CP to CP in 5 cases. There was no case demonstrating angiographical improvements in MCA aneurysms.

Two cases (29%) demonstrated angiographical worsening, CP to NR in 1 case and NR with worsening in 1 case.

In vertebral and basilar artery aneurysms, 3 out of 7 cases (43%) demonstrated no angiographical change. They were CP to CP in 3 cases. Two cases (29%) demonstrated angiographical improvements, PA to NR in 2 cases. Two cases (29%) demonstrated angiographical worsening, CP to PA in 1 case and PA with worsening in 1 case.

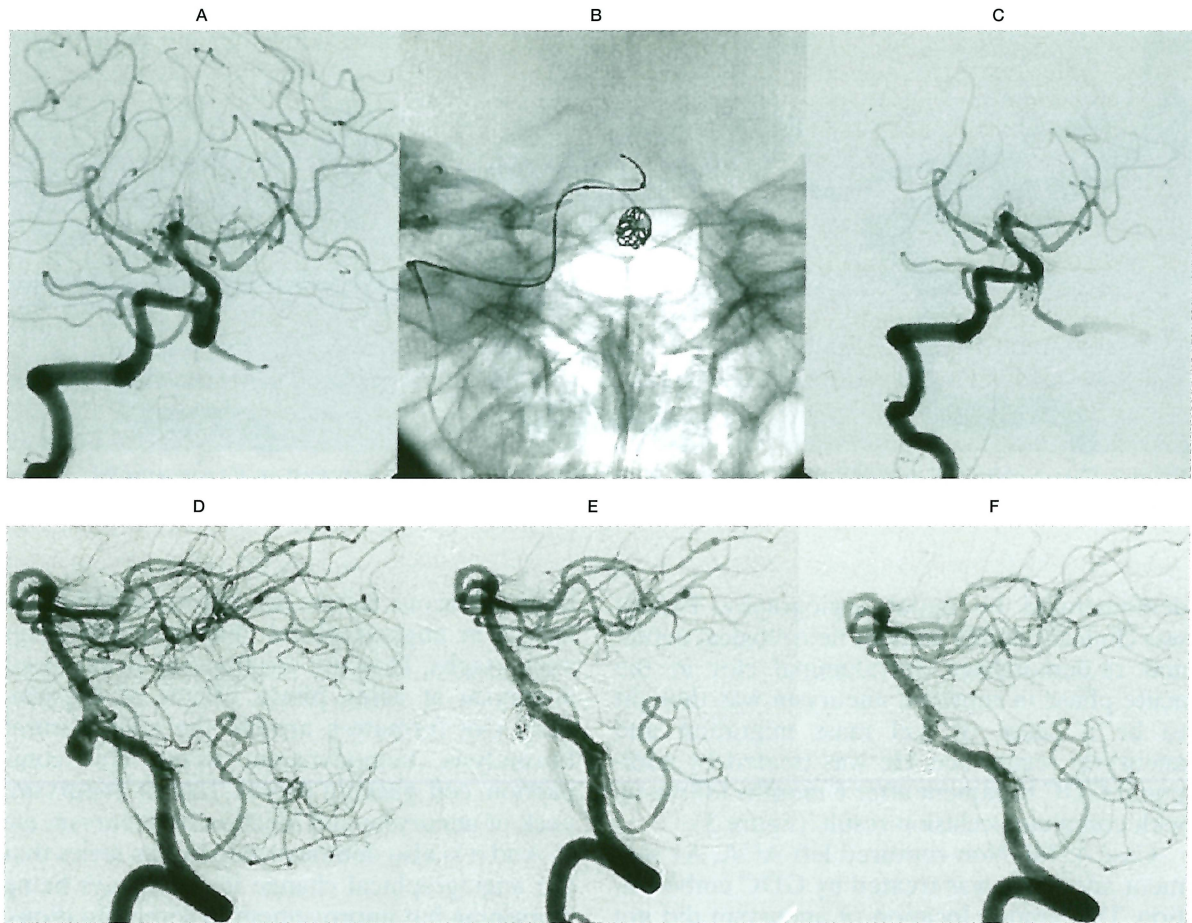


Figure 1 Case 1: right VA aneurysm. A) pre-embolization right VAG, B) during coil embolization, C) post GDC embolization, D) pre-embolization, E) post embolization, F) 6 months F/U angiography.

Final angiographical outcomes

Final angiographical outcomes of 45 patients in this series were complete occlusion in 26 cases (58%), neck remnant results in 9 cases (20%) and partial occlusion in 7 cases (16%). There were one case of rejecting follow-up examination, one case of lost follow-up and one case of surgical clipping after 6 months F/U. Three cases were treated by additional GDC embolization after the angiographical worsening at the F/U. The other incomplete occlusion cases were followed because the recurrent space was too small to treat with additional coil embolization. There was no case of hemorrhage or re-hemorrhage after GDC treatment.

Representative case reports

Case 1; 56F Non-ruptured right vertebral artery aneurysm associated with subarachnoid

hemorrhage from right ICA aneurysm was treated by GDC embolization with balloon neck plasty technique. Partial occlusion result with dome filling at post embolization angiography was improved to neck remnant result at 6 months follow-up examination. (figure 1).

Case 2; 62M Non-ruptured right ICA-choroidal artery aneurysm was treated by GDC embolization. Intentional partial occlusion to spare the origin of the anterior choroidal artery was angiographically worsening at 6 months follow-up examination by coil compaction and aneurysm regrowing. He was treated by surgical clipping after 6 months follow-up. (figure 2).

Case 3; 33M Ruptured ACA aneurysm was treated by GDC embolization in the acute phase with complete occlusion result. Six months follow-up angiography revealed aneurysm recurrence by migration of coil mass to the distal part of the aneurysm where was not

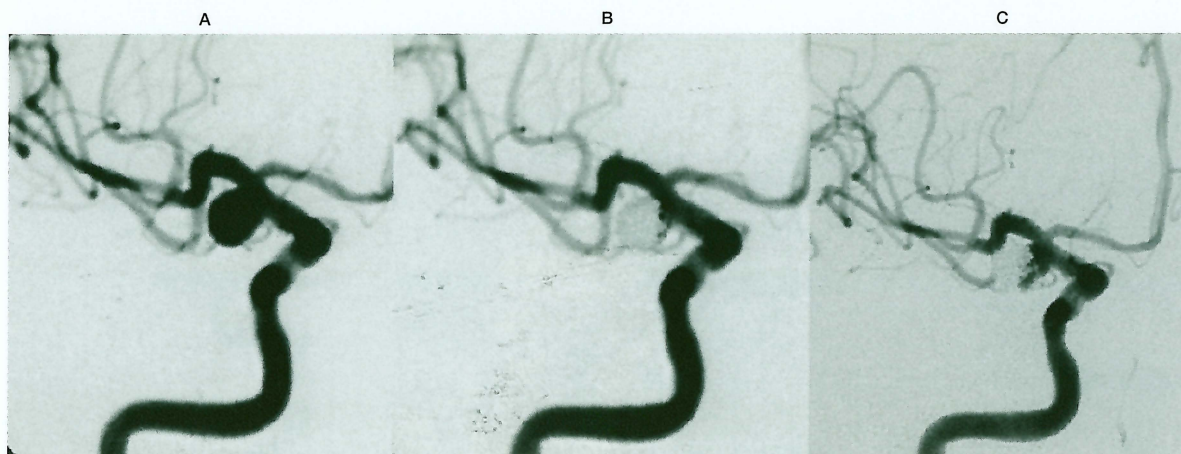


Figure 2 Case 2: right ICA choroidal artery aneurysm. A) pre-embolization, B) post embolization, C) 6 months F/U angiography.

demonstrated by initial angiography. Patient was clinically stable without neurological deficit and re-hemorrhage. Intraluminal clot in the acute phase in ruptured aneurysm was thought to be a cause of coil mass migration and aneurysm recurrence. He was treated by additional GDC treatment after 6 months follow-up with complete occlusion result. (figure 3).

Case 4; 74F Non-ruptured left ACA, A1 segment aneurysm was treated by GDC embolization. This unique location of aneurysm did not make it possible to pack aneurysm tight because of its difficult angle from the bifurcation of ICA. Dome filling and partial occlusion results at post embolization angiography improved to complete occlusion at 6 months follow-up examination. (figure 4).

Discussion

The results of aneurysm coil embolization are mainly dependent upon the geometrical factors of the aneurysm and the skillfulness of the operator how dense the aneurysm was packed^{2,4}. The results of this series are made by one averaged technique endovascular operator and not characterized by special technique or experienced technique.

It is well known that the final result of GDC aneurysm embolization is not determined by post embolization angiography. Aneurysm recurrence with or without coil compactions at the follow-up angiography was sometimes experienced even in patients with complete occlusion result at the post embolization angiography⁷.

Various factors are known as influence factors in angiographical change in follow-up angiography. They are coagulopathy in ruptured aneurysm at acute phase, effects of heparin, early clot formation around the coils, natural fibrinolysis, hemodynamic stress, coil compaction, coil packing degree, size of aneurysm, neck of aneurysm and location of aneurysm etc²⁻⁸. And it is also demonstrated in this series that the angiographical change is not always being worsening but improvement in some situations. Most of the angiographical changes were recognized at 6 months follow-up and there was no case of angiographical worsening after complete occlusion result at follow-up angiography. Timing of follow-up angiography is still controversial problem in relation with medical cost and invasiveness of the angiography. It may be better to perform the follow-up angiography less than 6 months, 1 month or 3 months, to catch when the angiographical change occur. And as the most of the angiographical worsening was occurred with coil compactions, skull plain film examination could detect early change of coil compactions instead of performing invasive examination of cerebral angiography. Another problem in timing of follow-up is when we can stop follow-up and make a cure diagnosis for GDC treated aneurysm. About 10 years experience of this treatment could not conclude this problem because the aneurysm characteristics was too various. And we have some information about the recurrence situations such as aneurysm geometry. In this series most of the aneurysms were small aneurysms

and non-ruptured aneurysms and most of the angiographical changes were recognized at 6 months F/U⁷. This result may be changed in cases of including large size, giant aneurysms or in series of purely ruptured aneurysms.

Angiographical improvement

Angiographical improvements of GDC aneurysm embolization in follow-up angiography are mainly caused by progressive thrombosis of the aneurysm space. The aneurysm with tightly packed coils and small residual space is easily thrombosed at the early stage and it was complete occlusion at the post embolization angiography. The aneurysms with roughly packed coils and dome filling result at the post embolization angiography changed to complete occlusion at the follow-up in some cases in this series. These angiographical improvements are found at 12 cases (28%) out of 43 patients at 6 months follow-up. Eight of 11 were case of side-wall aneurysm such as ICA aneurysms. There was no case of angiographical improvement at 12 and 24 months follow-up. These improvements are found in patients with side-wall aneurysms such as ICA aneurysms and small neck aneurysm cases. In patient with aneurysm with tightly packed its inflow side is also demonstrating angiographical improvement. Intra-aneurysmal flow is dramatically changed by inserting coils into the aneurysm especially in side-wall aneurysm case or small neck aneurysm case. And the residual space is tends to be thrombosed easily by being separated the aneurysm lumen from blood flow. Inflow side tightly packed case has same effect in thrombo-

sis of the residual space. These aneurysm geometry and flow dynamics factors are thought to be main factors of the angiographical improvements. And another factor of the angiographical improvements is that post embolization angiography was performed under the full heparinization and the estimation of occlusion was made by this angiography. With the end of heparin effect, the residual space was progressively thrombosed and it may result angiographical improvements in follow-up angiography. And technically, packing coils of the aneurysm may be relatively loose in this series, so it may cause less complete occlusion rate and angiographical improvements may be found in one-fourth of the patients in this series.

Angiographical worsening

Angiographical changes at the follow-up angiography usually mean angiographical worsening such as aneurysm recurrence or aneurysm regrowth with or without coil compaction⁷. In this series, eleven cases out of 43 cases (26%) demonstrated angiographical worsening at 6 months follow-up. All the case demonstrated minimal to moderate coil compactness. One case was necessary to be treated by surgical clipping, two cases were treated by additional GDC embolization and the other cases were followed because the recurrent spaces were very small. Three cases demonstrated angiographical worsening at 12 months follow-up.

Two of these were demonstrating progressive worsening from 6 months to 12 months follow-up. A case of ACA aneurysm was classed

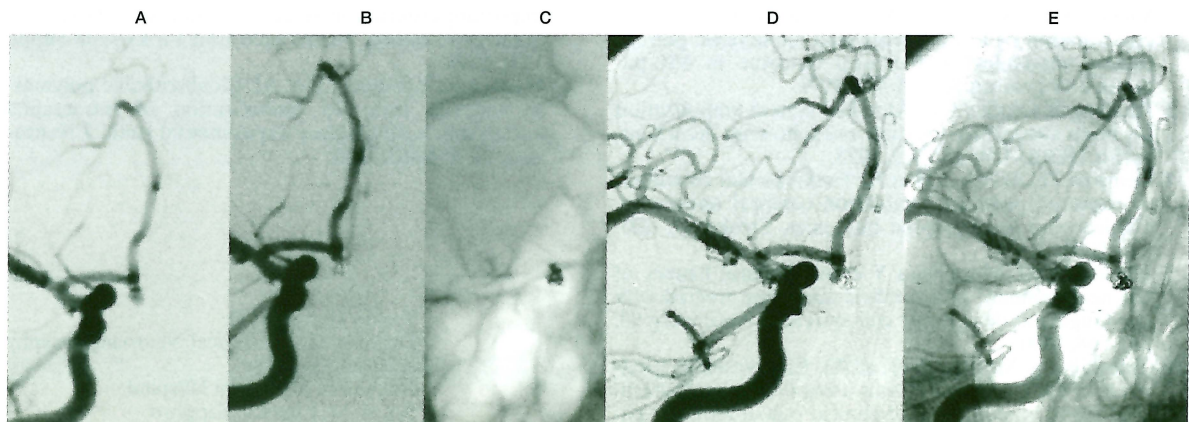


Figure 3 Case 3: ruptured ACA aneurysm. A) pre-embolization, B) post embolization, C) plain skull film with same oblique view, D) 6 months F/U angiography, E) 6 months F/U angiography and migrated coil mass.

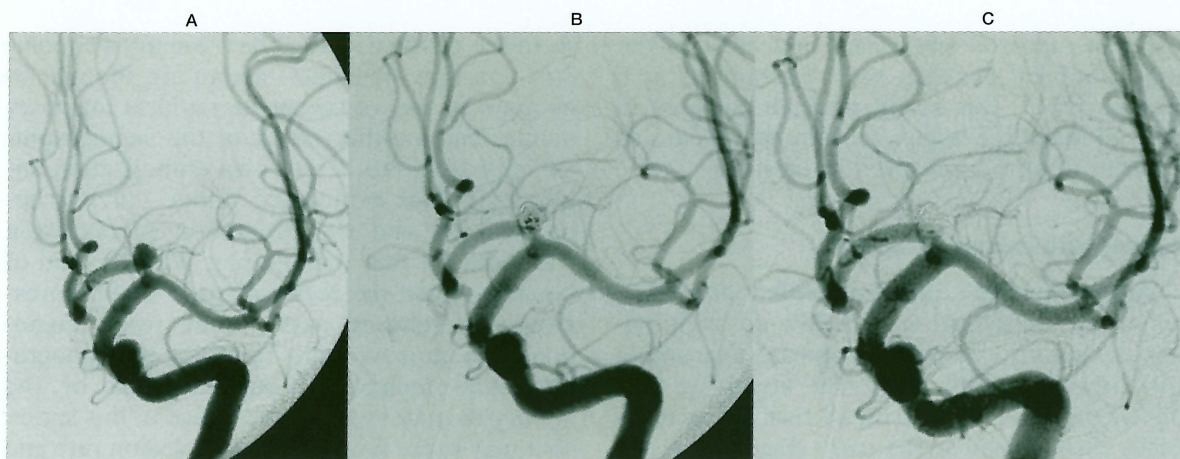


Figure 4 Case 4: left ACA A1 segment aneurysm. A) pre-embolization, B) post embolization, C) 6 months F/U angiography.

from CP to PA because of improper follow-up angle of the angiography, there was no coil compaction in this case. There was no case of angiographical worsening at 24 months follow-up and no case of subarachnoid hemorrhage from the treated aneurysms. Possible causes of coil compactions were wide neck aneurysm in 5 cases and/or bifurcation aneurysm in 6 cases where the hemodynamic stress directly affected upon the aneurysm.

In one case, aneurysm recurrence by migration of coil mass to the distal part of the aneurysm was found and intraluminal clot and natural fibrinolysis of the ruptured aneurysm was thought to be a cause of coil mass migration and aneurysm recurrence. (Case 3) Recent

research for modification of the coil will be a great help for this coil compaction and the angiographical worsening⁹.

Conclusions

Most of the angiographical changes were recognized at 6M F/U. Angiographical improvements were found in side wall and small neck aneurysms, and inflow side tight packing case. Angiographical worsening was recognized with coil compaction and in case of bifurcation aneurysm and/or wide neck aneurysm. Partial occlusion result with wide neck aneurysm became progressive worsening at the follow-up and early additional treatment was necessary.

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